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COLORING SATSUMA ORANGES IN ALABAMA.[1]

By R. C. Wright, *Physiologist, Office of Horticultural and Pomological Investigations, Bureau of Plant Industry.*

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INTRODUCTION.

It is well known that citrus fruit grown under certain climatic and cultural conditions may be mature and highly desirable for food while the skin of the fruit is still green in color. This is especially true of the Satsuma[2] orange as grown in Alabama, where the fruit frequently reaches a stage of physiological maturity at which it is palatable and attractive as an article of diet some weeks before it attains the characteristic golden yellow color. In general, when it reaches full color on the trees the fruit in this region is characterized by a low acidity, with a comparatively high sugar content, and the overripe fruit is inclined to be insipid in flavor. It is important, then, if this fruit is to be furnished the consuming public in its most desirable condition for food, that it be harvested before it becomes yellow on the trees.

Danger of frost in this region after November 15 and the fact that the best market for this orange is in the early fall after the main portion of the California Valencia crop has been harvested and before the early oranges from Florida are mature enough to ship are further reasons for marketing this fruit early. On the other hand, green-colored fruit, no matter what the quality, is difficult to

[1] The writer's thanks are due Dr. O. F. E. Winberg, president of the Gulf-Coast Citrus Exchange, for much constructive advice and many courtesies.

[2] Satsuma oranges belong to the same group of mandarin or "kid-glove" oranges as the tangerine. Only two varieties of the Satsuma orange are commonly grown in this country, viz, the Ikeda and the Owari.

merchandise. In the mind of the consuming public a green-colored orange is immature and unfit for food. The public desires fruit for decorative purposes as well as for eating, and a well-colored orange is much more attractive than one green or partially green in color. The green-colored fruit is therefore at a decided disadvantage in competitive selling. It is evident then that some method of treating this fruit so that it would assume a rich orange-yellow color early in the season, when it was most desirable for food, would be of benefit to the industry and to the consuming public alike. Such a process has been developed in California for the coloring of lemons.

These lemons are usually picked to size, irrespective of color. The green fruit is placed in suitable storage where a temperature ranging from 55° to 60° F. is maintained with a humidity of about 85 per cent. During the winter months or when the demand is light the fruit may be left under these conditions, and the desired yellow color will develop usually in from three to six weeks. When, however, there is sufficient demand, coloring may be resorted to and the lemons made ready for market in from three to six days. Until the result of work by Sievers and True [3] became known, the coloring was thought to be due to the heat and humidity of the rooms rather than to the fumes from the kerosene stoves used to furnish heat. However, it had been noticed that when the old type of kerosene stove was replaced by the more modern odorless type that was developed about that time, less desirable results were obtained, and careful experiments by the above-mentioned workers showed that the change in color of the fruit from green to yellow was due chiefly to the effect of the gas and not to the heat or humidity of the coloring rooms.

This method of coloring citrus fruit should not be confused with the old sweating process, which consisted in holding the fruit in a hot room until it either became yellow or rotted. In the process now employed the change in color is brought about by the destruction of the chlorophyll in the cells of the rind with a consequent appearance of the yellow color, which was present but masked by the green.

Oranges, both navel and Valencia, as well as lemons, are colored by this process in California, and it was considered possible that it might be well adapted to the peculiar conditions existing in the Satsuma orange industry in Alabama.

MATURATION OF SATSUMA ORANGES IN ALABAMA.

Satsuma orange growing as a commercial industry is confined to the two southernmost counties in Alabama, Baldwin and Mobile. At present about 15,000 acres are planted, of which about one-fourth are in bearing. The fruit is usually fully colored by November 1, but, as has been said, it is physiologically mature and desirable for food some time before this date. This is shown in a series of experiments the results of which are given in Tables 1 to 3. In these experiments the soluble solids and acidity were determined after the

[3] Sievers, Arthur F., and True, Rodney H. A preliminary study of the forced curing of lemons as practiced in California. U. S. Dept. Agr., Bur. Plant Indus. Bul. 232, 38 p., 4 fig. 1912.

method described by Rose[4] on oranges from both Mobile and Baldwin Counties. Table 1 gives the results of tests on samples of oranges collected between October 4 and 15 from different groves. They represent fruit grown under somewhat different methods of culture and in some cases quite different soil conditions. Each sample consisted of 12 average oranges taken from as many different trees.

Table 1.—*Determinations of solids, acidity, and color of oranges from different groves in Baldwin and Mobile Counties, Ala., picked October 6 to 15.*

Locality and sample.	Date collected.	Citric acid.	Soluble solids.	Solids-acid ratio.	Yellow color.
Mobile County:		*Per cent.*	*Per cent.*		*Per cent.*
No. 1	Oct. 6	0.82	8.00	9.7	15
No. 2	...do.....	1.16	10.00	8.6	0
No. 3	...do.....	.88	9.00	10.2	10
No. 4	...do.....	.86	8.00	9.3	0
No. 5	Oct. 9	.79	10.15	12.8	20
No. 6	...do.....	.88	9.72	11.0	30
No. 7	...do.....	1.00	9.22	9.2	5
Baldwin County:					
No. 1	Oct. 3	1.14	9.75	8.5	0
No. 2	...do.....	1.08	8.81	8.1	0
No. 3	Oct. 4	1.05	9.22	8.7	0
No. 4	Oct. 6	1.28	9.00	7.0	0
No. 5	Oct. 7	1.08	8.74	8.1	0
No. 6	...do.....	.90	9.68	10.7	5
No. 7	...do.....	1.06	8.67	8.2	0
No. 8	...do.....	.94	9.68	10.3	0
No. 9	Oct. 9	1.07	8.15	7.6	10
No. 10	Oct. 13	.96	9.35	9.8	5
No. 11	...do.....	1.15	10.35	9.0	5
No. 12	Oct. 15	.76	9.22	12.1	20
No. 13	...do.....	1.15	9.22	8.0	10

It will be noticed in Table 1 that with but two exceptions all the oranges proved to be at or above the ratio of 1 part citric acid to 8 parts soluble solids. The greenest colored of these fruits on being cut open showed a full rich golden yellow color of the flesh, and they were entirely satisfactory to the taste, in most cases being sweet and full of juice. Further results with samples taken from time to time from two groves are given in Tables 2 and 3.

Table 2.—*Determinations of solids, acidity, and color of oranges from a single grove, picked at intervals from September 13 to November 8.*

Date.	Citric acid.	Soluble solids.	Solids-acid ratio.	Yellow color.
	Per cent.	*Per cent.*		*Per cent.*
September 13	1.77	9.00	5.1	0
October 3	1.15	9.75	8.5	0
October 14	1.15	10.15	8.8	10
October 27	.99	11.22	11.3	20
November 8	.84	11.20	13.3	100

On September 13 the oranges were entirely green in color, but on being cut open the flesh was seen to be yellow with a greenish tint and was not palatable. By October 3, while the color of the peel was still green, it had begun to turn light in spots, the color

[4] Rose, R. E. Immature citrus fruit. Laws, rules, and regulations. Instructions to growers for applying the "ratio of acid to total-solids test." Revised Aug. 20, 1918. Tallahassee, Fla.

of the flesh had fully developed, and the solids-acid ratio was greater than 8 to 1. The taste was still somewhat sour. By October 14 the fruit was entirely satisfactory to the taste, while only a small amount of yellow showed about the calyx. By October 27 only 20 per cent of yellow color had developed. On November 8 the fruit was practically full colored.

Studies of many tests made in the field seem to show that shortly after full orange color develops the acidity of the fruit tends to decrease to such an extent that it becomes insipid in flavor, while the pulp portion of the fruit separates from the peel. A high ratio of soluble solids to acid does not apparently indicate in all cases a high flavor. The soluble solids were seldom above 10.5 per cent, while the acid late in the fall frequently drops to 0.5 per cent, or even lower, thus giving a high ratio. Two sets of samples which were taken periodically from two different locations in a certain grove show how the acidity decreases toward the end of the season, rendering the fruit less sprightly in flavor than it was a month or six weeks earlier. Fruit from this grove was not fully colored on the tree until about November 12. Table 3 shows the results of four solids-acid tests made between September 16 and November 15. While the acid in fruit from location A decreased from 1 per cent to 0.49 per cent and in location B from 1.1 per cent to 0.45 per cent, the soluble solids in A increased from 7.6 per cent to 10.3 per cent and in B from 7.6 per cent to 9 per cent. The ratio of soluble solids to acid therefore increased in location A from 7.6 to 21 and in location B from 6.9 to 20.

TABLE 3.—*Determinations of solids, acidity, and color of oranges from a single grove picked at intervals from September 16 to November 15.*

Date.	Location.	Citric acid.	Soluble solids.	Solids-acid ratio.	Yellow color.
		Per cent.	*Per cent.*		*Per cent.*
September 16	A	1.00	7.6	7.6	0
	B	1.10	7.6	6.9	0
September 29	A	.88	7.5	8.5	10
	B	.90	8.5	9.5	15
October 29	A	.52	8.5	16.3	20
	B	.54	8.5	15.7	50
November 15	A	.49	10.3	21.0	90
	B	.45	9.0	20.0	100
	C	.34	9.0	26.5	100

It is evident then that the fruit will in practically all cases pass the test prescribed for oranges in interstate commerce by food inspection decision 182 of the United States Department of Agriculture, which provides that the "juice of the mature fruit contains not less than eight parts of soluble solids to each part of acid calculated as citric acid without water of crystallization," which is usually some time before it attains full color on the tree.

It is also apparent from the results of the experiments just described that the color of the skin of an orange is no criterion of its physiological maturity nor of its attractiveness and desirability as

an article of diet. If the fruit is allowed to remain on the tree until it attains a full golden yellow color it is liable to be somewhat insipid and not at all as desirable for eating as it would have been earlier in the season.

EXPERIMENTAL WORK IN COLORING SATSUMA ORANGES.

EXPERIMENTS IN 1919.

The experiments in coloring Satsuma oranges described in this bulletin were begun in 1919 at Silverhill, Ala., and continued in 1920 and 1921. The first efforts were entirely unsuccessful because the stoves were not properly adjusted to give off the necessary gas. Both kerosene portable heaters and ordinary cookstoves of the blue-flame cotton-wick type were used. These were operated in the ordinary way, allowing complete combustion with no perceptible offensive fumes. The experimental house in which this work was carried on comprised three rooms 6 by 12 feet with 6-inch flooring laid with half-inch open spaces between. The stoves were located below each room in pits which communicated with the outside. For the first experiments, because of the comparatively small quantities of fruit used, a false ceiling was erected in each room about 3 feet above the floor. The temperature was maintained at about 90° F., with a humidity between 60 and 85 per cent. Kerosene and a so-called "gas oil," a low-grade distillate, were used singly and combined in various proportions in the stoves, but the green color of the fruit remained practically unchanged even after as long a period as 10 days. When kerosene alone was burned a slight color change was noted, but it developed so slowly that the fruit began to break down before any considerable change took place. It became quite evident that Satsuma oranges could not be satisfactorily colored by operating kerosene stoves in the ordinary way. This is in accord with the results obtained in California by Sievers and True with lemons. They found that "heat and humidity are of minor importance in coloring lemons and that the pungent gaseous combustion products given off by the oil stoves used produced the desired effect."

In connection with the preliminary coloring experiments it was observed that after five or six days in the coloring rooms the oranges were much improved in flavor. This change in flavor was accompanied by an increase in the solids-acid ratio; that is, the acid decreased while the soluble solids increased, thus making a sweeter fruit. This is shown by the analyses given in Table 4.

TABLE 4.—*Increase in solids-acid ratio in four lots of Satsuma oranges during coloring in 1919.*

Lot.	Color stage.	Citric acid.	Soluble solids.	Solids-acid ratio.	Lot.	Color stage.	Citric acid.	Soluble solids.	Solids-acid ratio.
		P. ct.	*P. ct.*				*P. ct.*	*P. ct.*	
Lot A	Before coloring	1.25	8.60	6.9	Lot C	Before coloring	0.88	7.52	8.5
	After coloring	1.15	9.82	8.5		After coloring	.82	8.81	10.8
Lot B	Before coloring	1.25	8.60	6.9	Lot D	Before coloring	.90	8.53	9.5
	After coloring	1.20	9.82	8.2		After coloring	.81	8.81	10.9

For the next experiments the stoves were adjusted so as to give off the pungent fumes characteristic of incomplete combustion. Care was taken that smoke was not given off at the same time. In order to maintain the humidity as high as possible the ground beneath the floors was kept constantly wet by throwing in several buckets of water daily. A lot of 30 field boxes of Satsuma oranges was put in a coloring room on October 20. To maintain a high humidity a stove was operated continuously with a pan of water over the burner. Some of this fruit showed a little yellow color about the calyx when placed in the coloring room, but most of it was entirely green. It was found that during the day when the outside temperature was high the additional heat from the stove kept the temperature within the room around 85° to 95° F. with a humidity of about 60 per cent, while the night temperature was from 75° to 80° with a humidity of about 70 per cent. In five days a satisfactory color had developed, which subsequently changed very little. A blackening and shriveling of the calyx and the stem were noted. The fruit should have been removed at this time, for at the close of the experiment, October 29, the stems, or buttons, were all so loose that they readily rubbed off, and in addition the fruit was slightly off flavor. In Table 5 are shown the results of analyses of samples from this lot at the start, October 20, also on October 24 and October 29. In addition, the analysis is given of a check sample of 24 fruits that were held in a separate building. This check sample showed no change in color at the close of the experiment, although its solids-acids ratio had increased.

TABLE 5.—*Change in the solids-acid ratio of Satsuma oranges in coloring when the stove was operated continuously.*

Time of observation.	Date, 1919.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Start	Oct. 20	0.90	8.74	9.7
Fifth day	Oct. 24	.87	9.82	11.2
Close	Oct. 29	.78	9.61	12.3
Check	...do	.78	8.60	11.0

In the next experiment, on October 29, 30 boxes of fruit similar to that used in the preceding test were put in a coloring room with the stove operated only at night. In this way the fruit received less gas. The humidity was maintained at an average of about 70 per cent. As in the preceding experiment, the desired color was practically fully developed on the fifth day, with little subsequent change.

TABLE 6.—*Change in the solids-acid ratio of Satsuma oranges in coloring when the stove was operated only during the daytime.*

Time of observation.	Date, 1919.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Start	Oct. 29	0.73	8.67	11.8
Sixth day	Nov. 4	.72	9.47	13.1
Close	Nov. 6	.70	9.47	13.5
Check	...do	.69	8.50	12.3

At the close of the test (November 6) the stems were loose. On the fifth day, while the stems had not become loose, they were somewhat blackened and shriveled. The change in the solids-acid ratio during coloring is shown in Table 6. The check sample of 24 fruits stored in a separate building did not change in color.

In the earlier experiments it was found that the oranges were well colored in about five days, but most of the stems were loosened and there was considerable shrinkage, ranging from 5 to 6 per cent of the original weight of the fruit. For the next experiments the false ceilings previously mentioned were removed in order that the room might be filled. It was expected that with the larger quantity of fruit a higher humidity could be maintained.

On October 29, 125 boxes of Satsuma oranges were put in a coloring room and the stove operated continuously. This fruit showed slightly more yellow color at the beginning of the test than that of the former lots, as most of the fruit was slightly colored around the calyx. On the fourth day the fruit was about 50 per cent colored. Owing to the colder weather the minimum night temperature had been about 72° F. An oil heater was then installed for use at night, in order to maintain the temperature at about 80° F. at all times. The humidity throughout this experiment was about 70 per cent. This experiment was closed on November 6, when the desired color had fully developed. About 50 per cent of the stems were loose, and practically all the rest showed the blackening of the calyx and stem which was noted in the earlier experiments. The shrinkage was nearly 5 per cent of the original weight. The results of the analyses of these fruits are shown in Table 7. It should be mentioned here that in all the experiments, in order to insure a representative sample for analysis, two to six fruits were selected at random from each box and kept in a separate container. From these the sample of 12 fruits was drawn for analysis.

TABLE 7.—*Change in solids-acid ratio in coloring a lot of 125 boxes of Satsuma oranges.*

Time of observation.	Date, 1919.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Before coloring	Oct. 29	0.73	8.67	11.9
Fifth day	Nov. 4	.71	9.47	13.3
After coloring	Nov. 6	.70	9.47	13.5
Check	..do....	.69	8.50	12.3

On November 6 another lot of 150 boxes of oranges from the same grove as those used in the former experiment was put in a coloring room. In order to keep the humidity of the room as high as possible it was sprayed twice a day with water by means of a knapsack sprayer. By this method a humidity of about 85 per cent was obtained. This fruit did not color up as fast as that of the earlier experiments, for two reasons. The stove did not give off as strong fumes as before, and this lot of fruit was coarse and rough, being the last picked from the grove. At the time of picking the natural color was practically as far advanced as that of fruit picked earlier, but, as stated, the texture was coarse. The smoother skinned oranges

of better quality, which ripen first, had been picked. Later experience showed that rough, coarse fruits color up slowly in the coloring rooms, just as they color up slowly on the trees, although their actual solids-acid content may be about the same as that of smoother fruit.

This experiment closed on November 12, when the desired color was about 70 per cent developed. It was feared that a prolonged exposure to the gas would interfere with the palatability of the fruit. In fact, a slight off flavor had already developed in some individual fruits. The oranges were left undisturbed for two or more days without any gas in the room. During this time full orange-yellow color had developed. Weighed samples showed no appreciable shrinkage or loss in weight. Solids-acid tests made at the beginning and at the close of the experiment are shown in Table 8, as are results of similar tests on a check lot that was held in a separate building and in which the color was apparently unchanged.

TABLE 8.—*Change in solids-acid ratio in a lot of 150 boxes of Satsuma oranges during coloring.*

Time of observation.	Date, 1919.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Start	Nov. 6	0.72	8.46	11.8
Close (seventh day)	Nov. 12	.62	9.38	15.1
Check	...do....	.62	8.88	14.3

For the last experiment of the season of 1919 two lots of Satsuma oranges, 32 boxes in all, were picked from two different groves. The oranges were carefully selected smooth-skinned fruits, with 10 to 15 per cent natural orange color. These were put in the room November 18 and removed November 22. The stove was operated continuously, and the fruit was sprayed with water twice daily. In spite of this spraying there was an average loss in weight of 2 per cent. At the close of the experiment the desired color was fully developed and the flavor excellent. These oranges were stored in a packing house until the last of the month, at which time the first fruit colored on the trees came into this particular house. The fruit colored by gas was packed in separate marked boxes and shipped to Chicago with a car of oranges colored on the trees. They were sold in the auction along with the other fruit, but as a separate lot. The gassed lot sold at a somewhat higher average than the rest of the carload. The boxes of these oranges when opened presented a better appearance because the pack was tight on arrival, the usual shrinkage having taken place during the coloring process before they were packed.

The results of the solids-acid tests made at the beginning and at the close of the experiment as well as the results obtained in the check sample which did not show any change in color at the end of the experiment are presented in Table 9. It will be noted that in lot A the solids-acid ratio was the same in the check as the colored fruit, while in lot B this ratio was higher, due probably to a variation in samples.

TABLE 9.—*Change in the solids-acid ratio in two lots of Satsuma oranges during coloring.*

Lot and time of observation.	Date, 1919.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Lot A:				
Before coloring	Nov. 18	0.73	8.88	12.2
After coloring	Nov. 22	.67	9.22	13.8
Check	..do....	.67	9.22	13.8
Lot B:				
Before coloring	Nov. 18	.66	8.88	13.4
After coloring	Nov. 22	.66	9.22	14.0
Check	..do....	.59	9.22	15.6

EXPERIMENTS IN 1920.

During the season of 1920 it was determined to test the use of gasoline-engine exhaust, since engines were used for power in all the packing houses, and the exhaust gas would be readily available for this purpose. There was some danger from fire where stoves were used in the same building with the fruit. The first lot was started on October 20. These oranges showed from 5 to 10 per cent yellow color. The engine was run from noon until 11.30 p. m. October 20 and for 12 hours each of the following three days, the temperature averaging between 75° and 80° F., while the humidity was maintained at about 85 per cent by means of a humidifier,[5] which was operated by the engine that furnished the exhaust. Briefly explained, this humidifier consisted of parallel pieces of terry cloth or Turkish toweling about 24 by 24 inches suspended from raised slots in a pan of water 24 by 18 inches. These wet cloths, or wicks, were held tightly at the bottom in another pan which caught the drip from the cloths. The sides were inclosed, while the ends were open. Air from a blower was forced through this arrangement and took up water from the wet cloths. The humidifier and blower were set inside the room, being operated by a belt through the wall from the engine just outside. At the beginning of the experiment the humidity of the room was 62 per cent. An hour's operation of the humidifier raised it to 80 per cent. The outside humidity averaged during the day between 60 and 70 per cent and at night about 83 per cent. At the end of four days the desired color was fully developed, while the stems were green and tight and the flavor excellent. The solids-acid tests before and at the close of the experiment are shown in Table 10.

TABLE 10.—*Change in the solids-acid ratio in the first lot of fruit colored by the engine exhaust.*

Time of observation.	Date, 1920.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Before coloring	Oct. 20	1.40	9.75	6.9
After coloring	Oct. 23	1.13	10.01	8.9

[5] Shamel, A. D. A humidifier for lemon curing rooms. U. S. Dept. Agr. Bul. 494, 11 p., 7 figs. 1917.

The next lot of oranges was placed in the coloring room on October 25. This lot was treated five days under the same conditions as the lot just described. The temperature averaged somewhat lower, ranging between 70° and 75° F., while the humidity was kept at about 85 per cent. This lot of fruit was rougher and thicker skinned than the last lot, but averaged about 25 per cent yellow color. At the end of five days the color was about 90 per cent developed, but after two more days without any gas it was fully developed. The solids-acid tests before and at the close of the experiment are shown in Table 11.

TABLE 11.—*Change in the solids-acid ratio in the second lot of oranges colored by the engine exhaust.*

Time of observation.	Date, 1920.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Before coloring	Oct. 25	1.16	9.61	8.3
After coloring	Oct. 29	1.16	9.97	8.6

The first house constructed for commercial coloring was of a maximum carload capacity, holding from 350 to 400 field boxes. It was papered with single-ply felt roofing and boarded and battened outside; also papered with red rosin-sized building paper and boarded on the inside of the studding, leaving an air space between. There were also double doors with a 4-inch air space between. The roof was covered with ordinary 2-ply roofing felt. The inside dimensions of the room were 20 by 20 by 6 feet to the plate. The floor was of material 6 inches wide laid with half-inch interspaces. The building stood on a concrete foundation about 3 feet high. A door through the foundation allowed entrance to the space below. The first lot of fruit was started in this house on November 7 and consisted of 400 field boxes of about 100 pounds each. A 1-horsepower engine was installed just outside this house, with the exhaust pipe extending through the foundation to the center of the space beneath the floor. The humidifier was set up just inside the building and operated by the engine.

The fruit was about 25 per cent yellow colored when picked and was the second picking from the grove. The oranges, therefore, were not as thin skinned or of as fine texture as those of the earlier picking, but were of a very good quality. The engine was run for 10 hours each day for four days, and an average humidity of 90 per cent and a temperature of 72° F. were maintained during that time. At the end of four days the fruit was fully colored, the stems remained green and tight, and the flavor was excellent. There was practically no shrinkage. It was also noted that the texture of the oranges was much improved, and they had a velvety feel not found in the fruit colored on the trees. This lot was packed in marked boxes and shipped to Chicago in two mixed cars with fruit colored on the trees. The processed fruit arrived on the market in good condition and was as desirable and sold as well as the oranges colored on the tree.

The results of the solids-acid tests made at the beginning and at the end of the experiment are shown in Table 12.

TABLE 12.—*Change in the solids-acid ratio in a carload of oranges during coloring.*

Time of observation.	Date, 1920.	Acid.	Soluble solids.	Solids-acid ratio.
		Per cent.	*Per cent.*	
Before coloring	Nov. 7	1.23	10.00	8.1
After coloring	Nov. 10	1.20	10.35	8.6

There was an increase in the solids-acid ratio due to increase in the soluble solids. Practically no decrease took place in the acid content, possibly because of the uniformly low temperature of the coloring room throughout the period.

Two lots of fruit were colored in the season of 1920 after November 10. Most of the oranges by this time had colored on the trees, though a few groves here and there showed little or no yellow color. There was danger, of course, that such fruit would be damaged by early frost, and so the crop of one grove that showed practically no color was treated in two successive lots of slightly more than a carload each. Probably because this fruit was rather rough, thick skinned, and of poor texture as compared with the average, it took seven days to color each lot. The engine was kept running 10 hours each day. With both lots the temperature and humidity averaged practically the same as in the experiments just described. No solids-acid tests were made. It seemed probable at the time that these two lots of fruit would be damaged by frost if they were allowed to remain on the trees until they attained a full yellow color, as they would not have colored until well along in December.

EXPERIMENTS IN 1921.

Encouraged by the results in 1920, the Gulf Coast Citrus Exchange in 1921 took up the coloring of Satsuma oranges on a commercial scale. Coloring houses with capacities of from one to three cars were constructed in conjunction with each of their packing houses. Although oranges from a number of groves passed the solids-acid ratio of 8 to 1 as early as October 3, coloring was not started until October 15. After this date, as fast as the coloring houses were completed and equipped they were filled and started. These houses were all operated continuously throughout the season. Coloring was accomplished in each case by utilizing the exhaust from the gasoline engine used to operate the sizing machinery. By means of appropriate fittings this exhaust was controlled in such a way that it could be discharged into any one or all of the rooms as desired. When the inlet valves were once set each day to admit the required quantity of gas for each room, usually no further care was needed, as an exact quantity of gas is not important. The usual tendency was rather toward using too much gas than too little. As the packing houses were operated only during the day, the coloring rooms received no gas at night. When proper care was exercised against allowing too much exhaust to be discharged into the rooms, the stems on the fruit remained perfectly tight. In one or two instances, however, where the exhaust did become too strong the stems were loosened. In two instances temporary trouble was caused

by the engines throwing off black smoke with the exhaust, which ceased when the engines were properly adjusted. The humidity in all but one case was maintained by hanging 15 or 20 wet sacks in the room each day. In dry hot weather several buckets of water were thrown on the floor twice daily. This water running through the slat floors kept the ground below wet. In this way the humidity was easily maintained at about 80 per cent. In the one other instance the humidifier previously described in this bulletin was used. In practically every lot of fruit colored (about 80 per cent of the entire output was colored as described) the oranges came out fully and uniformly colored, with tight stems and unimpaired flavor and quality. The average shrinkage was less than 1 per cent. The time required to color the oranges varied according to the degree of natural color already present when the fruit was put in the room. Oranges showing up to 20 per cent of natural yellow color usually required four days to develop full yellow color in the coloring room. Where more of the orange-yellow color was present when the fruit was placed in the room less time, of course, was required. Experience showed that it was even desirable at times to put into the coloring room oranges that showed only a green tint or that were not uniformly colored. Usually one day sufficed to put a uniform color on such fruit.

The results of the solids-acid tests made at different coloring houses, with notes as to the condition of the fruit, etc., are shown in Table 13.

TABLE 13.—*Determinations of solids, acidity, and color of oranges at different coloring houses in 1921.*

[The increase in acidity of the two samples marked with asterisks (*) was probably due to variations in sampling.]

Coloring house.	Date of start, 1921.	Time required (days).	Color at start.	Acid.	Soluble solids.	Solids acid ratio.
			Per cent.	*Per cent.*	*Per cent.*	
A	Oct. 15	4	15	0.92 .88	Before coloring, 9.54 After coloring, 9.72	10.4 11.0
B	Oct. 18	3½	10	1.03 .88	Before coloring, 10.18 After coloring, 10.29	9.9 10.6
C	Oct. 19	3	50	.88 .88	Before coloring, 9.47 After coloring, 10.18	10.8 11.5
D	Oct. 20	4	15	.74 .65	Before coloring, 9.47 After coloring, 9.68	12.8 14.9
E	Oct. 22	4	5	1.09 .99	Before coloring, 10.41 After coloring, 10.29	9.5 10.4
F	Oct. 26	4	10	.90 .99	Before coloring, 9.68 After coloring, 10.18	10.7 *10.3
G, room 1	Oct. 25	....	40	.99 .91	Before coloring, 10 18 After coloring, 10.47	10.3 11.5
G, room 2	...do....	....	10	.84 .93	Before coloring, 9.17 After coloring, 9.47	10.9 *10.1
G, room 3	...do....	....	40	.84 .68	Before coloring, 8.67 After coloring, 9.47	10.3 13.9

Near the end of the season (1921) an improved kerosene-stove gas-generating outfit was installed at one of the coloring plants, in

order to compare the results of this method with the engine-exhaust method already in use. A concrete gas-generating house, 5 by 8 feet and 5 feet high, was built about 20 feet from the coloring house. From near the roof of this house, gas generated by a four-burner asbestos-wick kerosene stove with perforated pieces of tin placed loosely over the chimneys of each burner was drawn through 5-inch galvanized-iron rain spouting and forced by means of a blower into the coloring rooms. This being a 2-room house a Y with a damper in each branch served to divert the gas into the desired room. Two cars of oranges were satisfactorily colored with this outfit.

THE COLORING PLANT.

CONSTRUCTION OF AN INEXPENSIVE COLORING PLANT.

In Figure 1 is shown a plan for the construction of a typical 2-room coloring house. Each room is 20 by 20 by 6 feet to the plate inside and holds one maximum carload in field boxes. This plan is adaptable to the requirements of the individual packing house and can be used for the construction of a single room or as many more rooms as are necessary. The cost of such a 2-room house should not exceed $500, using rough or undressed lumber throughout. In practice it is found that a 1-room plant can not be operated as efficiently as a 2-room house, since with two rooms the work of coloring and packing can be carried on continuously while alternating the coloring rooms. If a small-capacity coloring plant only is desired it would be advisable to have at least two rooms each of a carload capacity or less. Preferably the coloring house should be built in conjunction with the packing house (Fig. 2), with the floor on a level with that of the packing house, so that when colored the fruit can be trucked directly into the packing house. There should be enough space below the floor to allow free circulation of gas, which is introduced into this space. The walls and roof are papered and boarded on both sides of the studding and rafters to make the building more nearly air-tight, to prevent the loss of the gas from within the house, and to provide dead air space between the studding for insulating the interior against extremes of heat and cold.

The coloring house should be built on a solid 8 to 10 inch concrete foundation, on which is bolted a 2 by 6 inch sill set in cement. For a house of more than one room concrete partitions in the foundation should be constructed to correspond with the rooms. An entrance provided with a small tight-fitting door should be placed in the foundation under each room.

The frame should be of 2 by 4 inch studding set on 2-foot centers, and 2 by 6 inch rafters on 16-inch centers, with a 1 by 6 inch collar beam for each second rafter. The walls and partitions should be double sided and papered. The exterior siding of thoroughly seasoned material should be well nailed over single-ply felt roofing paper (not tar paper). The inside walls may be of close-fitting ordinary sheathing material nailed inside the studding over ordinary building paper. The roof should be covered with a 2-ply or 3-ply roofing paper cemented as well as nailed along the seams. It is

advisable to construct a tight ceiling over the room at the height of the plate, two ventilator openings being left to correspond with the roof ventilators.

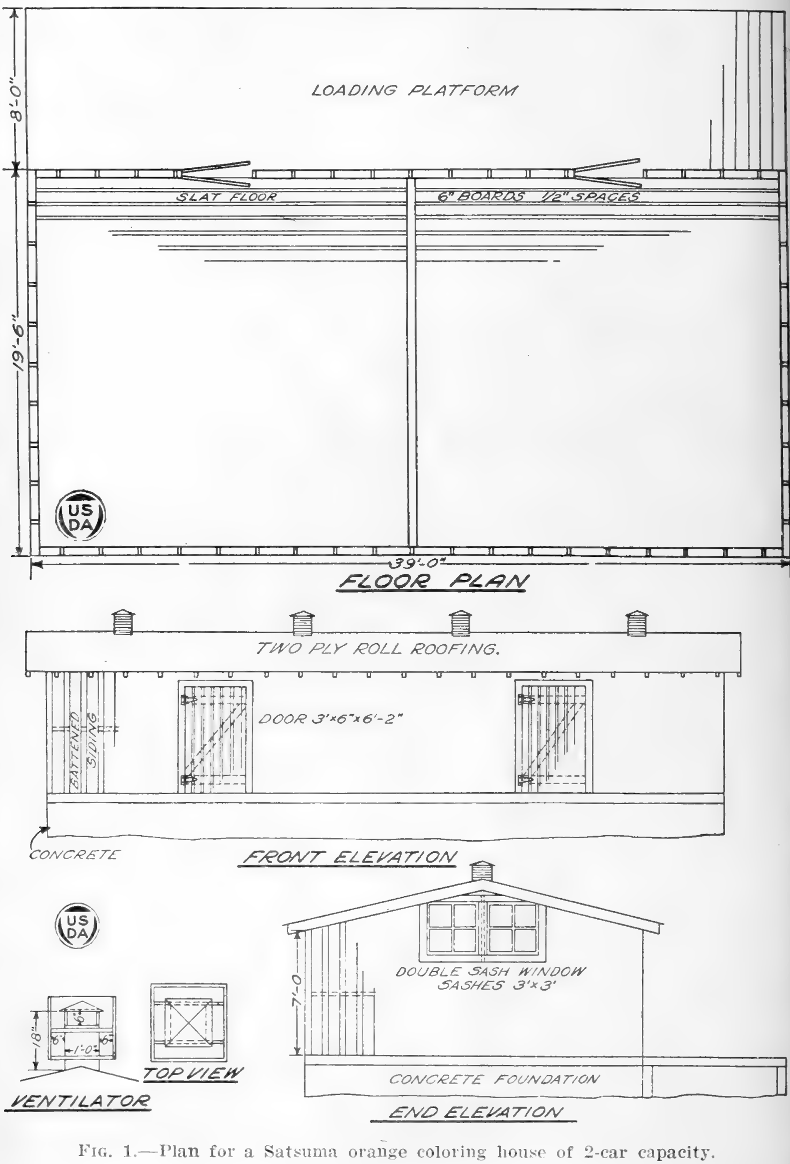

FIG. 1.—Plan for a Satsuma orange coloring house of 2-car capacity.

The floor should be of 1 by 6 inch boards laid with one-half inch spaces between.

The joists should be 2 by 10 inch set on 12-inch centers and resting on three 8 by 8 inch parallel girders placed equidistant apart so

as to make the bearings not over 5 feet apart. The girders should be supported on 8 by 8 inch concrete piers placed 5 feet apart.

The ventilators should be equipped with tight-fitting doors which can be operated with rope pulls from the inside.

The entrance to each room should have two tight-fitting doors with an air space between. If the coloring house is built adjacent to a packing house, similar doors for each room should be provided between the two buildings. Every precaution should be taken to make the building as nearly air-tight as possible. Special attention should be directed to the securing of tight unions about the sill and plate.

EQUIPMENT OF A COLORING PLANT.

Where a coloring house having two or three rooms is to be operated, the coloring can usually be successfully carried on by

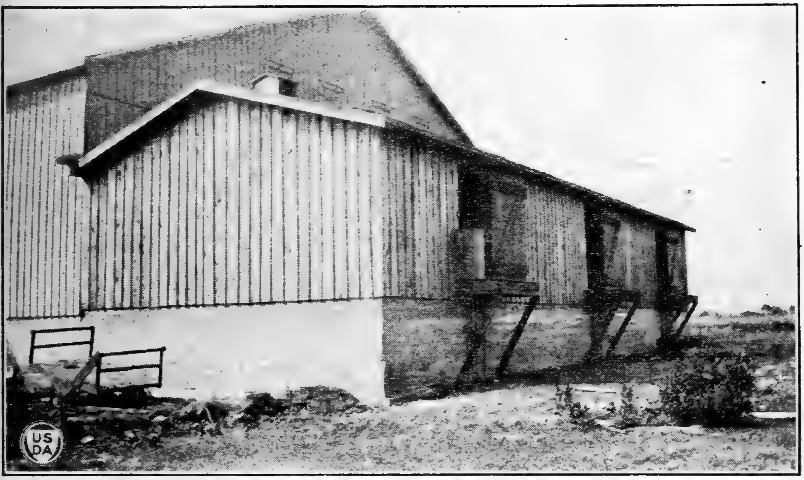

FIG. 2.—Satsuma orange coloring house built in conjunction with a packing house.

using the exhaust gas from the gasoline engine in case one is used to furnish power for the sizer in the packing house. If a larger house is to be operated or if a gasoline engine is not used for power in the packing house, it is advisable to use the kerosene-stove equipment, which will be described.

EQUIPMENT FOR COLORING WITH ENGINE EXHAUST.

The gasoline engine ordinarily used in the Alabama packing house, described in this bulletin, is of 6 to 10 horsepower with an exhaust outlet of from $1\frac{1}{4}$ to 2 inches in diameter. The exhaust can be piped directly to the basement of each room by using suitable fittings, without lowering the efficiency of the engine too much.

The piping and fittings required are described as follows: Close to the engine a union should first be used so that the engine can readily be disconnected for making repairs, etc. Then, conveniently close to the engine, is located a T if two rooms are to be served or a cross in case of three rooms. At each of the two or three outlets thus

left, gate valves of suitable size are connected by 4-inch nipples. From each gate valve lines are run to one of the rooms, using 45° elbows wherever possible instead of ordinary 90° elbows, as the latter tend to increase back pressure on the engine. By locating the gate valves close together it is found more convenient to control the gas supply for each room. Between the engine and the group of valves just described it is advisable to locate another T, with an additional gate valve connected into the side outlet and with a length of pipe leading to the outside for carrying off all or part of the exhaust in case it is not required in the coloring rooms. Kerosene engines should not be used for coloring, as experience has shown that this type gives off smoke in the exhaust which will be deposited on the oranges.

EQUIPMENT FOR COLORING WITH GAS FROM KEROSENE STOVES.

Because of fire risk it is not desirable to locate in the coloring house the stove used for generating the gas. The most desirable arrange-

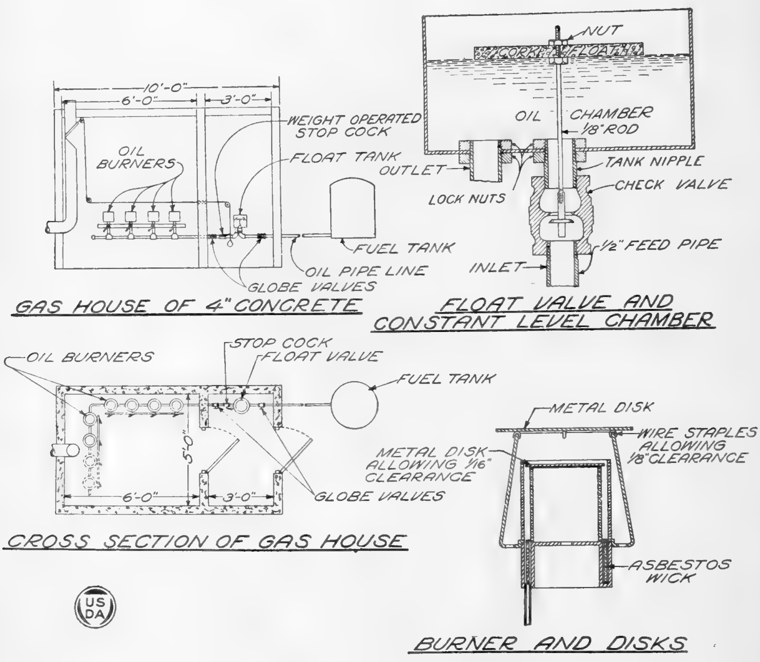

FIG. 3.—Plan for a gas-generating house.

ment is the system followed in California, where gas is generated in a separate fireproof building 40 to 80 feet distant from the coloring rooms. The gas from near the top of the generating house is drawn through a conduit and forced into the coloring rooms. A plan for such a gas-generating room, of concrete, is shown in Figure 3. A house built according to this plan will accommodate 12 or more burners, which will generate a maximum of gas to supply a 6-room coloring plant. The stoves ordinarily used in these plants consist usually

of the manifolds and burners and are without the sheet-iron stove frame, though ordinary kerosene cookstoves with absestos wicks can be used. The stoves usually employed for this purpose have short asbestos wicks and a tubular sheet-iron chimney. In practice a piece of perforated metal is placed loosely over the chimney of each burner (see detail drawings in Fig. 3), thus interfering with the draft. This results in a lack of oxygen for complete combustion of the vaporized kerosene, and the pungent sootless gas is given off. This gas from the burner room is drawn out and forced by means of a power blower through a conduit of galvanized-iron pipe, 6 to 12 inches in diameter, to the coloring house, where it is conducted to the basement of each of the rooms. The oil-feed line, as shown in the plan, runs through the anteroom, where the constant-level float valve and the safety valve are located. The supply tank is located outside. The safety valve is operated by a weight suspended by a cotton cord extending over all the burners. The cord also supports a safety damper in the outlet pipe in such a position that the gas can pass freely from the generating room to the coloring house as long as the burners are burning well. In case any of the burners flame up, as frequently happens, the cord burns and the oil supply is cut off; at the same time the damper drops, closes the gas outlet, and opens the flue, and the smoke and soot are passed out into the outside air.

MANAGEMENT AND OPERATION OF A COLORING PLANT.

PICKING THE FRUIT.

From an efficiency point of view, the management of a coloring house should begin in the orchard by the selection of proper fruit for coloring. During the first week or 10 days of the season care is necessary in selecting the fruit, as only that which is well advanced in maturity irrespective of color should be selected. After some experience the maturity of the fruit may be determined by the texture and "feel," in conjunction with the solids-acid test. Only the softer and finer textured fruits should be picked early. The coarse-textured hard fruit should be left for later harvesting. During this first picking the workers need very close supervision. Ordinarily, if the second picking is a week or 10 days later the trees may be picked clean. There will usually be found a mixture of green-colored fruit and more or less tree-ripe or fully colored fruit all of which are physiologically mature and ready to pick. If only a small percentage of this fully colored fruit is present it can be picked with the rest of the oranges, but it should be placed in separate containers and sent direct to the packing house. However, if many of the oranges on the trees are fully colored it is best to have the green fruit and colored fruit picked by separate gangs of pickers. Care should be taken to separate the green from the yellow-colored oranges, as fruit colored on the trees or fruit that is nearly full colored before picking should never go into the coloring house with green fruit, even if the proportion is small, because these fruits may become unpalatable, soft, and out of condition by the time the others are colored and ready for market. A good pack can easily be injured by a few overripe fruits which may spoil before reach-

ing the market. It is sometimes a good practice, however, to sort out the oranges showing 80 per cent or more yellow color and put them in a separate coloring room, or even near the door in a room with the others, so they can be removed in about 24 to 36 hours, when they are uniformly colored. Careful handling of the fruit is very important and should be insisted upon in picking, grading, and packing.

FILLING THE HOUSE.

The green oranges should be hauled immediately from the field in the regular field crate and stacked five or six crates high in the coloring room, with an aisle through the center of the room. When the room is filled it should be closed up tight and the gas turned on.

HUMIDITY OF THE ROOMS.

If a humidifier is not used, several wet bags or some material of a similar nature should be hung over the edges of the boxes along the aisle. If the weather is hot and dry, it is well to keep the ground below the fruit wet by throwing a few buckets of water on the floor in the aisle. With these precautions the shrinkage should be kept down to 1 per cent or below.

OPTIMUM TEMPERATURE AND VENTILATION.

If it can be avoided, the temperature should not exceed 80° F. In hot weather the best and perhaps the only practical method of keeping the temperature down is to keep the humidity high and to open at night all the ventilators and doors, including the small doors below the floor. In this way the cool, moist night air, having free circulation, will cool the fruit so that the following day a considerably lower temperature may be maintained than would be possible if the house were kept closed at night. On the other hand, the temperature should not be below 70° F. or the coloring will be slowed down and the fruit may be injured by prolonged exposure to the gas. Therefore if the weather is cool the house should be kept closed at night to conserve the heat that accumulates during the day. If this procedure will not suffice, then it is sometimes advisable to put a small kerosene heater in the room. If a generator house is used for furnishing the gas it is a comparatively simple matter to produce more heat to meet such a condition, without increasing the volume of gas, by burning one or two extra burners without the gas-generating attachments.

AMOUNT OF GAS.

As there is no means of measuring the concentration of gas in a coloring room, the operator must learn by experience to determine the amount present. This is not at all difficult. The amount of gas necessary is comparatively small, as with an oversupply there seems to be danger of loosening the stems on the fruit. On entering a well-regulated room one should experience only a slight disagreeable odor and a burning sensation of the eyes. It is not necessary to stay in the room, as the first sensation experienced on enter-

ing is the most reliable. One should not stay in a coloring room more than a minute or two at any time while there is gas present, as severe headache and nausea are likely to result. If the concentration of gas is strong, a prolonged stay in the coloring room is liable to induce sudden collapse or even death. For these reasons it is well, as a matter of precaution, to post danger notices on the door of each coloring room.

Present experience indicates that the coloring process should be intermittent. A convenient and successful practice has been to keep the gas in the coloring room during the period of the regular working day of about 10 hours. At night the room is ventilated, as already described. Circumstances, of course, may make variations in this program desirable. If the room is not filled and ready to start until evening, a day may be saved by immediately turning on the gas for 8 or 10 consecutive hours. The following day the regular program may be followed.

TIME REQUIRED.

Ordinarily coloring will be complete in four days if the fruit is sufficiently matured and carries at least 5 per cent of yellow color when placed in the room. In proportion as the oranges have colored on the tree the time required in the coloring room will be lessened. In practice it will be found desirable at times, in order to keep the field forces busy and to save time in the packing house as well, to send in fruit so nearly colored that only a greenish tinge is noticeable. When such fruit is given one day in the coloring room a full uniform color will usually develop.

In bringing out the desirable full golden yellow color characteristic of the Satsuma orange the greatest difficulty will be experienced with the first pick of the season. Sometimes in the early fruit that is processed four days in the usual way the color developed will be a lemon yellow instead of the desirable golden yellow. Such fruit should be colored more slowly by turning in the gas for perhaps two hours in the morning and again in the afternoon each day for five or six days, keeping the humidity high and the temperature as near 75° F. as possible. This ordinarily will apply to only the first one or two carloads to be colored.

THE SOLIDS-ACID TEST.

Great care should be exercised to see that all oranges to be colored will pass the Federal requirements as set forth in Food Inspection Decision 182, United States Department of Agriculture, 1921, which requires that the juice of oranges entering interstate commerce shall contain "not less than eight parts of soluble solids to each part of acid calculated as citric acid without water of crystallization." The coloring of oranges which do not meet this requirement could be interpreted as an effort to conceal inferiority. This precaution will insure the market against fruit that is immature and unpalatable and help maintain the reputation of the Satsuma orange for high quality and flavor. Fruit that does not pass the solids-acid test and is colored by the process described in this bulletin can not, according to the regulation, be shipped in interstate commerce. The solids-acid test is simple and only requires careful

attention to the details of titration and a reading of the hydrometer. With a little practice a test can be made in a compartively short time. The apparatus and chemicals required can be purchased from any reputable chemical supply house. The entire outfit can be packed in an ordinary suitcase and carried from place to place.

Directions are here given for making the solids-acid tests, compiled from directions furnished by the Bureau of Chemistry of the United States Department of Agriculture and by the Florida Agricultural Experiment Station.

APPARATUS REQUIRED.

A Brix spindle, graduated in tenths of a degree, ranging from 0° to 15°.
A Fahrenheit or centigrade chemical thermometer.
A 25 cubic centimeter pipette.
A 50 cubic centimeter burette graduated in tenths of a cubic centimeter.
A burette support.
A glass cylinder, approximately $1\frac{1}{4}$ inches in diameter by 12 inches high.
A small glass funnel.
Two 500 cubic centimeter Ehrlenmeyer flasks for titrations.
A lemon squeezer or reamer.
A granite-ware cup of 1 liter capacity.
A piece of muslin about 18 by 18 inches for straining the juice.

SOLUTIONS.

A standard solution of sodium or potassium hydroxid, 1 cubic centimeter of which is equivalent to 10 milligrams of citric acid (without water of crystallization) (factor 0.01), or a normal solution, 1 cubic centimeter of which is equivalent to 64 milligrams of citric acid (factor 0.064) or a tenth normal solution (factor 0.0064).

A saturated solution of phenolphthalein in 80 per cent alcohol for use as indicator (best contained in a 2-ounce dropping bottle).

DIRECTIONS FOR MAKING THE TEST.

Sampling.—In order to make the sample as representative as possible, not less than 12 oranges are used, preferably taken from several trees. They are halved or quartered, depending upon the size, and the juice removed as thoroughly as possible with a lemon squeezer or reamer. Care should be taken to remove the juice from all parts of the orange and as thoroughly as possible, for the composition is not the same in the center as next the skin. The juice should be well mixed and strained through a muslin cloth.

Solids.—A glass cylinder is filled three-quarters full with the juice and a Brix spindle placed in it. A sufficient quantity of juice is then added to overflow the cylinder. The spindle is allowed to remain for a few minutes, in order to allow the air in the juice to escape, care being taken to see that the spindle does not touch the sides of the cylinder. The reading is then taken, the line just at the top of the liquid being the one read. The temperature of the solution is now noted, the bulb of the thermometer being placed in the juice and gently tapped against the sides of the container until the mercury column becomes stationary. The total solids is now found by reference to Table 14.

ACID.

(1) Fill the 25 cubic centimeter pipette by drawing it full of the liquid and allow the excess to flow back into the container until the upper level of the juice is opposite the zero line. Now, permit the contents to flow into one of the titration flasks. Do not hurry the flow by blowing into the pipette.

(2) Add 5 to 10 drops of the indicator solution from the dropping bottle to the juice.[6]

(3) Fill the burette with the standard solution until the top of the liquid is level with the zero line.

(4) Add the solution from the burette to the juice in the titration flask slowly, shaking the flask constantly until the juice assumes a yellow color and finally attains a pinkish tint, which indicates that the end point is reached and that all the acid in the solution is neutralized.

(5) As soon as the pink color is observed, stop the flow of solution from the burette. Note the quantity of solution used from the burette. This is indicated by the figure at the point opposite the height of the solution.

(6) To ascertain the percentage of acid in the 25 cubic centimeters of juice taken, multiply the quantity of solution used by the factor for 1 cubic centimeter of the solution which was used, either standard or normal, then divide by 25 plus one-tenth of the Brix reading.

TABLE 14.—*Corrections for temperature differences from 15° to 31° C. in determinations of the percentage of total soluble solids by the Brix hydrometer.*

[EXAMPLE: Reading of Brix hydrometer=8, temperature of juice=29° C. By referring to the table the total soluble solids is found to be 8.74 per cent.]

Temperature.	Brix reading.						
	6	7	8	9	10	11	12
59.0° F. (15° C.)......per cent..	5.89	6.89	7.88	8.88	9.88	10.88	11.87
60.8° F. (16° C.)..........do....	5.93	6.93	7.92	8.92	9.92	10.92	11.92
62.6° F. (17° C.)..........do....	5.98	6.98	7.97	8.97	9.97	10.97	11.97
64.4° F. (18° C.)..........do....	6.03	7.03	8.03	9.03	10.03	11.03	12.03
66.2° F. (19° C.)..........do....	6.08	7.08	8.08	9.08	10.08	11.08	12.08
68.0° F. (20° C.)..........do....	6.14	7.14	8.15	9.15	10.15	11.15	12.16
69.8° F. (21° C.)..........do....	6.20	7.21	8.21	9.22	10.22	11.22	12.23
71.6° F. (22° C.)..........do....	6.26	7.27	8.28	9.29	10.29	11.29	12.30
73.4° F. (23° C.)..........do....	6.32	7.33	8.34	9.35	10.35	11.35	12.36
75.2° F. (24° C.)..........do....	6.38	7.39	8.40	9.41	10.41	11.41	12.42
77.0° F. (25° C.)..........do....	6.44	7.45	8.46	9.47	10.47	11.47	12.48
78.8° F. (26° C.)..........do....	6.51	7.52	8.53	9.54	10.54	11.54	12.55
80.6° F. (27° C.)..........do....	6.58	7.59	8.60	9.61	10.61	11.61	12.62
82.4° F. (28° C.)..........do....	6.65	7.66	8.67	9.68	10.68	11.68	12.69
84.2° F. (29° C.)..........do....	6.72	7.73	8.74	9.75	10.75	11.75	12.76
86 0° F. (30° C.)..........do....	6.79	7.80	8.81	9.82	10.82	11.83	12.85
87.8° F. (31° C.)..........do....	6.86	7.87	8.88	9.89	10.90	11.91	12.92

Example: When titration was complete, as shown by the change in color of the juice to a pinkish tint, the height of the column of solution in the burette had fallen from zero to 23.3. This is multiplied by 0.01, the factor for 1 c. c. of the standard solution. The result is then divided by 25.87 (this figure is obtained by adding one-tenth of the Brix reading 8.74 to 25, the quantity of juice used).

$$23.3 \times 0.01 \div 25.87 = 0.9 \text{ per cent acidity.}$$

If a tenth normal solution is used, the height of the solution in the burette will fall to 36.4. Multiply this by 0.0064, the factor for 1 c. c. of a tenth normal solution. This result is then divided by 25.87.

$$34.6 \times 0.0064 \div 25.87 = 0.9 \text{ per cent acidity.}$$

[6] A better end point can be obtained if two volumes of water are added to the juice in the titration flask before titrating. Care must be taken, however, that the water is neither acid nor alkaline. This may be determined by adding a few drops of the indicator solution to the water. It should neither turn pink nor should it require more than a few drops of the standard alkali to turn a pink color. Keep the standard solution tightly stoppered when not in use. Wash out the burette and invert it in the support when not in use. Before measuring out the juice in the pipette rinse it with a small quantity of the sample you are about to run.

Ratio of soluble solids to acid.—To determine the ratio of soluble solids to acid divide the percentage of soluble solids (Brix reading corrected according to temperature) by the percentage of acid.

Example: Percentage of soluble solids, 8.74, divided by 0.9 equals 9.7; i. e., the ratio of soluble solids to acid is 9.7 to 1.

SUMMARY.

Satsuma oranges in Alabama become edible, palatable, and suitable for food some weeks before they assume a yellow or orange color on the tree.

Normally the picking of Satsuma oranges colored on the tree begins about October 15, but frequently, owing to seasonal variations in climate, picking is delayed from two to four weeks.

In certain sections local variations in environment tend to delay ripening or coloring.

The process of coloring as applied to the conditions in Alabama enables the growers to get their fruit on the market four to six weeks sooner than if it were left to color on the trees.

This procedure enables the growers to obtain better prices on the market and in addition serves to insure the crop against early frosts.

Coloring is accomplished by the action of the exhaust gas driven off by a gasoline engine or by the incomplete combustion of kerosene in a stove. This gas destroys the green chlorophyll which masks the yellow color.

Satsuma oranges to be colored should meet the requirements of United States Department of Agriculture Food Inspection Decision 182 and contain "not less than eight parts of soluble solids to each part of acid calculated as citric acid without water of crystallization."

Fruit carrying up to 40 per cent natural ripe color will ordinarily require four days in the coloring room to develop the full golder yellow color.

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